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The Impact of Prophylactic Fasciotomy Following Porcine (*Sus scrofa*) Hind Limb Ischemia/reperfusion Injury

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Background: Prophylactic fasciotomy has been used as an adjunct to alleviate the compartment syndrome after an ischemia reperfusion injury. It has been purposed that prophylactically treating compartment syndrome will improve neuromuscular recovery of the limb therefore improving functional limb outcome. The purpose of this study is to quantify the neuromuscular recovery of prophylactic fasciotomy in a porcine model of hind limb ischemia.

Method: Swine (*Sus Scrofa*; 76 +/-6kg) were randomly assigned to no fasciotomy or prophylactic fasciotomy after ischemia via external iliac artery occlusion and arteriotomy. Class III shock was induced via a 35% blood volume variable rate hemorrhage and external iliac artery repair was achieved after 0, 3, or 6 hours of ischemia. Prophylactic fasciotomy of the anterior compartment was performed at the time of reperfusion. Compound motor action potential, sensory nerve action potential, nerve conduction velocity and gait testing was evaluated during the 14-day survival period to calculate the composite physiologic model of recovery (PMR). Necropsy was performed for evaluation of nerve and muscle histology.

Results: In hemorrhage alone, according to the PMR the recovery was 94+/-28%, 63+/-37% and 55+/-44% at 0, 3 and 6 hours of ischemia respectively. A significant difference was noted between 0 and 6 hours of ischemia ($p<0.05$). With fasciotomy, a recovery of 97+/-72%, 98+/-80% and 42+/-39% was noted after 0, 3 and 6 hours of ischemia. Compound motor action potential showed the greatest decrement with ischemic insult. Histologic analysis is currently on going.

Conclusion: This study demonstrates the feasibility of fasciotomy in a porcine model. It validates the previous model of functional limb outcome with hemorrhage in a porcine model and shows an apparent trend towards improved functional limb outcome if vascular repair and prophylactic fasciotomy are performed within 3 hours of ischemic time.



The Impact of Prophylactic Fasciotomy Following Porcine Hind Limb Ischemia/Reperfusion Injury

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Introduction

Vascular injury is five times the rate of previously reported wars, with the majority of those injuries taking place in the extremities¹. Recent research has shown the ischemic threshold of 6 hours has been decreased to < 6 hours in the absence of hemorrhage² and < 3 hours in the presence of hemorrhage³. Prophylactic fasciotomy has been used to extend the ischemic threshold by alleviating compartment syndrome after ischemia reperfusion injury. The functional improvement after prophylactic fasciotomy has yet to be investigated in a translatable large survival model. The objective of this study is to establish a model of extremity compartment syndrome following vascular injury, hemorrhage and ischemia/reperfusion. An additional objective is to determine the effect of fasciotomy on measures of neuromuscular recovery. We hypothesize that prophylactic fasciotomy will improve functional outcome through the alleviation of compartment syndrome.

Methods

Thirty five female yorkshire swine (75+/-5kg) underwent 35% blood volume hemorrhage, followed by 1, 3 and 6 hours of ischemia via a right retroperitoneal iliac artery occlusion followed by standardized repair with dacron patch angioplasty and reperfusion (n=17; 1HR, 3HR, 6HR). A second cohort (n=18) underwent prophylactic fasciotomy of the anterior compartment of the hind limb following the blood volume hemorrhage and arterial repair, (1HR-F, 3HR-F, 6HR-F). Compartment pressures and measures of electromyographic (EMG) recovery were performed pre-operative, post-operative and on POD 1, 2, 7 and 14. The EMG variables were combined and compared to baseline to create the Physiologic Model of Recovery (PMR). On day 14, necropsy was performed and histologic analysis of the peroneus tertius and peroneal nerve was performed.

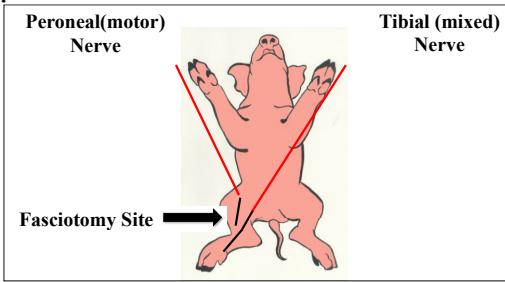


Figure. Location of Anterior Compartment Fasciotomy and Nerves evaluated for EMG. The peroneal nerve and peroneus tertius muscle are located within the anterior compartment.

Results

Compartment Pressures

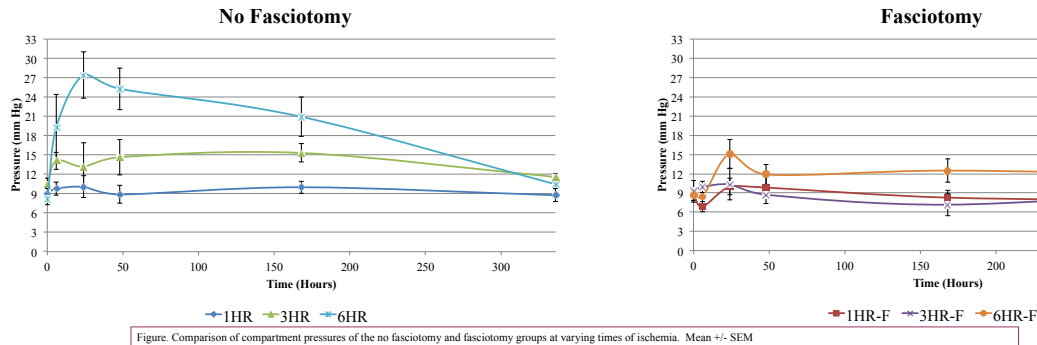


Figure. Comparison of compartment pressures of the no fasciotomy and fasciotomy groups at varying times of ischemia. Mean +/- SEM

Histologic Results

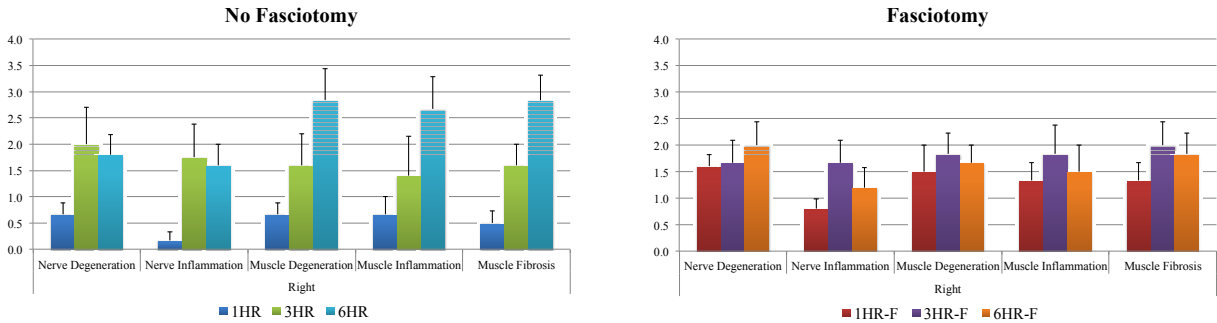


Figure. Comparison between the histologic grades of the peroneal nerve and peroneus tertius muscle between the fasciotomy and no fasciotomy groups. Mean +/- SEM
Y-Axis Scale: Muscle Score 0 = No Involvement 1 = 1-25% 2 = 26-50% 3 = 51-75% 4 = 76 - 100%, Nerve Score 0 = No Involvement 1 = Mild 2 = Moderate 3 = Severe Degeneration, Inflammation/Fibrosis 1 = Minimal 2 = Mild 3 = moderate 4 = Severe

Physiologic Model of Recovery

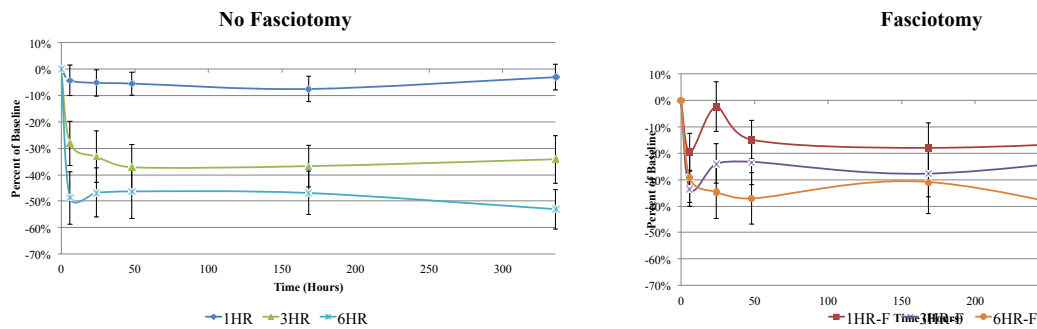


Figure. Physiologic model of recovery (combination of Compound Motor Action Potential (CMAP), Sensory Nerve Action Potential (SNAP) and Nerve Conduction Velocity (NCV)) comparison between groups. Mean +/- SEM

Variables Means (SE)	1 HR N=6	3 HR N=5	6 HR N=6	p-value	1 HR-F N=6	3HR-F N=6	6HR-F N=6	p-value
CMAP [mV]	10.3 (1.0)	5.8 (1.5)	3.2 (1.4)	<0.001	4.5 (0.3)	4.9 (1.3)	1.5 (0.7)	0.03
SNAP [uV]	15.0 (2.1)	8.1 (1.5)	5.0 (0.9)	0.04	11.5 (1.0)	11.3 (1.1)	5.1 (1.4)	0.005
AST [U/L]	44 (6)	45 (4)	52 (4)	0.65	50 (8)	45 (9)	50 (6)	0.80
Myoglobin [ng/mL]	63 (32)	39 (7)	39 (6)	0.42	48 (9)	23 (7)	21 (2)	0.36
Flows [cm/s]	59.8 (5.1)	68.3 (6.3)	61.1 (6.8)	0.08	64.2 (10.6)	44.5 (7.8)	65.1 (5.4)	0.10

Table. Characteristics at day 14.
One way ANOVA revealed a statistical difference among groups. Further analysis with post-hoc T-Tests revealed that CMAP and SNAP for the no fasciotomy group, 3 and 6 hours of ischemia were similar. These groups were different than 1 hour of ischemia. For the fasciotomy group, 1 and 3 hours of ischemia were similar, which was different that 6 hours of ischemia.
Duplex flow velocity and laboratory values to include, myoglobin, lactate, potassium, creatinine kinase, were not found to be different at the conclusion of the study.

Observations

- Compartment pressure had a statistically significant rise between all groups (1HR, 3HR & 6HR)
- Fasciotomy released compartment pressure in a statistically significant manner at 3 and 6 hours of ischemia.
- Increasing intervals of ischemia without fasciotomy showed worsening muscle damage that was mitigated by fasciotomy.
- Fasciotomy did not improve recovery at 6 hours of ischemia, 6HR 47 +/- 8% vs. 6HR-F 52 +/- 11%
- Fasciotomy at 3 hours of ischemia improved recovery, 3HR 66 +/- 9% vs. 3HR-F 81 +/- 9%

Conclusions

- Elevated compartment pressures can be obtained in a translatable model of ischemia/reperfusion injury.
- Fasciotomy successfully reduces compartment pressures and reduces the result for further damage caused by compartment syndrome.
- After 6 hours of ischemia in the presence of hemorrhage, fasciotomy does not improve the functional outcome of the limb
- Although not statistically significant, fasciotomy at 3 hours of ischemia with hemorrhage trended towards improved functional outcome.
- Fasciotomy moves the ischemic threshold from less than 3 hours to 3 to 6 hours.

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